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COMPREHENSIVE SCHOOL-BASED BEHAVIORAL ASSESSMENT OF THE EFFECTS OF METHYLPHENIDATE

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Individualized assessments of the effects of three doses of methylphenidate (MPH) were conducted for 2 students with attention deficit hyperactivity disorder within each child's classroom using behavioral, academic, and social measures. A double-blind, placebo-controlled, multielement design was used to evaluate the results. Results suggested that at least one or more dosages of MPH were associated with some degree of improvement for both children in each area of functioning as compared to placebo. However, the degree of improvement at times varied substantially across dosage and area of functioning. Results suggest that MPH dosage and area of child functioning are critical assessment parameters and that controlled clinical trials are necessary to optimize the effectiveness of treatment with MPH for the individual child.

DESCRIPTORS: attention deficit hyperactivity disorder, methylphenidate, behavioral assessment, behavioral pharmacology

Methylphenidate (MPH) is often effective for the management of a variety of classroom behaviors associated with attention deficit hyperactivity disorder (ADHD; e.g., Pelham, Bender, Caddell, Booth, & Moorer, 1985; Rapport, Murphy, & Bailey, 1982). However, children are often placed on MPH with little or no objective evaluation of medication effects. In addition, a determination of the effects of MPH for an individual child is complicated by several factors. First, individual differences in response to methylphenidate appear to be the rule rather than the exception (Pelham et al., 1993). Second, dose–response relations for an individual child may be linear (continued improvement with increasing dose) or quadratic (improvement to a peak effect followed by a decrement in performance), or reach a therapeutic threshold (improvement followed by no further change with increasing dose; DuPaul & Barkley, 1993). Thus, both overall effectiveness and an optimal dose may be very different for otherwise similar children. Finally, there is some evidence that response to MPH may vary within children across behavioral, academic, and social areas of functioning, both at the same and at different dosages (Forness, Swanson, Cantwell, Guthrie, & Sena, 1992; Sprague & Sleator, 1977).

The above literature suggests a number of limitations to previous evaluations of the effects of MPH. First, an overwhelming majority of studies have evaluated treatment effects based on subjective parent report, teacher report, and behavior rating scales. Unfortunately, these procedures are subject to informant bias and are often technically inadequate (Stoner, Carey, Ikeda, & Shinn, 1994). Second, most studies of children's response to MPH have reported results based on between-group statistical analyses. The use of single-case designs combined with standard drug evaluation procedures (i.e., double-blind placebo controls) has been

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rare. Third, only a few studies have included an adequate range of doses to evaluate individual dose–response relations. Finally, previous research has frequently included assessments of only one area of functioning (typically disruptive behavior). Thus, simultaneous effects (positive or negative) across other important areas of functioning (e.g., academics) often remain unknown.

The use of behavioral assessment methods with multiple assessment measures across dosage and behavioral domains has been previously suggested (DuPaul & Barkley, 1993; Fischer & Newby, 1991). Specifically, it has been recommended that school-based evaluations of MPH effects include at least (a) the use of reliable dependent measures that can be administered repeatedly without significant practice effects; (b) multiple measures that are directly relevant to classroom functioning (i.e., academic, social, and behavioral measures), as well as measures of potential side effects; (c) the use of single-case designs and double-blind control procedures; and (d) an assessment of multiple doses. However, the feasibility of such a comprehensive individualized assessment model has not been demonstrated, and it is difficult to include all of the recommended components in a practical and reasonably efficient model.

Although there is a need for a more comprehensive and individualized assessment of MPH effects, the best dependent measures for assessment remain unclear. Two behavioral assessment procedures that hold promise as reliable and sensitive measures of behavior change and academic performance are direct observation and curriculum-based measurement (CBM; Deno, Mirkin, & Chiang, 1982; Stoner et al., 1994). CBM can be used to assess a child's academic skills in areas such as reading, math, spelling, and written expression. A child's performance is measured using brief (1- to 3-min) reading passages and math worksheets that are derived from the student's current curriculum. Standard procedures have been developed to select multiple probes that can be used for frequent repeated measurement. Research has demonstrated the potential reliability and accuracy of CBM (Shinn, Good, Knutson, Tilly, & Collins, 1992). Stoner et al. demonstrated the utility of CBM of math and reading within a single-case design as a method for evaluating the effects of MPH on individual academic performance. Individual results suggested that CBM was a sensitive measure of medication effects, that academic performance varied across dosage within children, and that improvement occurred at an optimal dose for each participant.

The purposes of this study were (a) to develop a relatively practical and efficient model for evaluating the effects of MPH that addresses the limitations of current procedures as described above, (b) to determine the model's effectiveness at differentiating between MPH and placebo effects, and (c) to determine its utility for identifying an optimal dose of MPH for individual children. In addition, this study replicates and extends the findings of Stoner et al. (1994) by (a) further evaluating the sensitivity of CBM to medication effects and (b) providing a comparison of the results of curriculum-based assessment measures to simultaneous assessments of behavioral and social functioning.

METHOD

Participants and Setting

The participants were 2 boys of average intellectual functioning who met criteria for ADHD (American Psychiatric Association, 1994) and who had been receiving MPH prior to the study. Their respective parents and the physician prescribing MPH agreed that a medication evaluation would be beneficial.

Jacob, age 10 years, had been receiving 5 mg MPH (0.1 mg/kg) at 7:00 a.m. and 11:00 a.m. His teachers reported that he continued to talk excessively and made frequent interruptions during class time. Jacob had been previously diagnosed with dyslexia and read at approximately the first-grade level. Jay, age 11 years, had been receiving 15 mg (0.3 mg/kg) of MPH at 7:00 a.m. and 11:00 a.m. Jay's teachers reported continued problems with work refusal, inappropriate vocalizations, and inattention. Previous testing suggested that Jay was well above average in intellectual functioning and was reading at least 4 years above his placement in sixth grade. Both his teachers and parents reported frequent and severe problems with peer interactions. Informed consent was obtained from the parents of Jacob and Jay as well as from the parents of all peers who participated in a social interaction condition.

All assessment procedures were conducted at the child's school. Behavioral observations were conducted as unobtrusively as possible in the classroom by having observers positioned as far from the children as possible. Social interaction conditions were conducted in the school library or an empty classroom. CBM measures were conducted in the child's classroom at a table set apart from the rest of the students.

Assessment Procedure

Classroom observations of disruptive behavior. Behavioral observations were conducted in the classroom each day at the same time during a period of regularly scheduled independent seatwork. Target behaviors and definitions were based on the observational procedures for ADHD described by Barkley (1990a). Specifically, disruptive target behaviors were (a) inappropriate vocalizations, (b) playing with objects, and (c) out-of-seat behavior. *Inappropriate vocalizations* were defined as any vocal sound made by the child that was not preceded by raising a hand or acknowledgment from an adult. *Playing with objects* was defined as touching any object that was not at the student's desk and associated with the assigned task. *Out-of-seat behavior* was defined as the child's full body weight not being supported by a chair or the child's buttocks being removed from the chair for longer than 3 s.

Academic. For Jacob, 12 reading passages that contained at least 250 words were randomly selected from his reading textbook. Passages that contained a large amount of dialogue or proper names were not included. The examiner recorded the number of words read correctly and the number of errors made (e.g., omissions, substitutions, mispronunciations) as the student read aloud for 1 min from one of the 12 randomly selected passages. For Jay, passages that included comprehension questions were used because he could read the most difficult material in his curriculum at a mastery level. Jay was asked to read the passage silently, then answer 10 comprehension questions. There were no time limits associated with the task, and the number of comprehension questions answered correctly was recorded.

Math worksheets were developed to include a range of problems that represented the skills required by the child's current curriculum (e.g., single- or double-digit addition) and the correct proportion of problem type (e.g., 20% single-digit subtraction, 20% double-digit addition) as represented by the curriculum. Each student was given 5 min to complete as many problems as possible, and the number of correctly answered problems was recorded.

Social interaction. Social interaction between the target child and a group of 2 peers of his selection was observed during a structured play condition (preferred card games). Behaviors recorded during the social interaction condition were (a) appropriate social behavior, (b) inappropriate social behavior, and (c) nonsocial behavior. *Appropriate social*

behavior included the child initiating social contact, participating in the activity or following the rules of the activity, or any verbalizations made by the target child that were neutral, approving, friendly, pleasant, or complimentary. *Inappropriate social behavior* included disruption or interruption of an ongoing activity (e.g., cheating, going out of turn), aggressive physical behaviors toward a peer, or verbalizations that were threatening, aggressive, offensive, or derogatory. *Nonsocial behavior* was defined as the absence of appropriate or inappropriate social behavior during the observation interval (Whalen, Henker, Collins, Finck, & Dotemoto, 1979; Whalen et al., 1987).

ADHD Rating Scale. Teachers were asked to complete the ADHD Rating Scale (DuPaul, 1990; in Barkley, 1990b) at the end of each day based on the child's behavior during peak hours of medication effects. This scale contains 14 items that measure each of the symptoms of ADHD as defined by the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 1987). Each item corresponds to one of the symptoms, and the teacher rates the student's behavior on a Likert-type scale ranging from 0 (*not at all*) to 3 (*very much*). A total score was calculated daily for each child. The scale has been shown to be sensitive to stimulant medication effects (Barkley, 1990a).

Side effects rating scale. The Stimulant Drug Side Effects Rating Scale (SDSERS; Barkley, 1990b) was completed at the end of each day by the students' teacher and parents. The SDSERS ranges from 0 (*absent*) to 9 (*serious*) that is used to report whether the student experienced common side effects (e.g., headaches, stomachaches, insomnia) that are associated with the use of stimulant medication. A total side effects score was obtained daily by averaging all ratings across all items for each child.

Response Definitions and Measurement

Medication status. Each child's physician was asked to identify three dosages of MPH that he or she considered to be most appropriate to evaluate for each child. Jacob received 5 mg (0.1 mg/kg), 7.5 mg (0.2 mg/kg), 10 mg (0.3 mg/kg), and placebo. Jay received 5 mg (0.1 mg/kg), 10 mg (0.2 mg/kg), 15 mg (0.3 mg/kg), and placebo.

Data collection and interobserver agreement. All behavioral observations were conducted using a 10-s partial-interval recording procedure. All observations lasted 5 min. A second observer simultaneously but independently collected data for 33% of all sessions for Jay and 25% of all sessions for Jacob. Interobserver agreement was calculated on an interval-by-interval basis by dividing the total number of agreements by agreements plus disagreements and multiplying by 100%. Interobserver agreement for Jay's classroom observations and social interaction conditions averaged 97% (range, 90% to 100%) and 92% (range, 87% to 97%), respectively. Agreement for Jacob's classroom observations averaged 96% (range, 87% to 100%) and for social interaction conditions averaged 92% (range, 90% to 93%).

Agreement for reading and math was calculated by having a second observer score completed reading and math sheets. Interscorer agreement was assessed for 33% of all reading probes and math worksheets for Jay and 25% for Jacob. Percentage agreement was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Interoberserver agreement was 100% for each measure for both students.

Design

A double-blind, placebo-controlled, multielement design was used to evaluate results. Placebo and each dosage level were randomly alternated daily in accordance with a mul-

tielement design. All assessment procedures were completed each day until a minimum of three complete assessments were conducted at each level of medication. All medications were prepared by a pharmacist according to standard placebo procedures such that the placebo was similar in appearance to MPH. Daily doses were packaged, arranged in random order, and coded for future identification by the pharmacist. Parents were asked to initial a drug administration checklist after administering each dose to assess integrity. All assessment procedures were conducted within 1 to 2 hr after oral administration of either MPH or placebo.

RESULTS

Figures 1 and 2 show the results for Jacob and Jay, respectively, across each dosage as compared to placebo during classroom observations, during social interaction observations, and for math and reading performance. For clarity, each dosage is displayed separately rather than in the random order in which they occurred. The dosage order can be determined by examining the session numbers.

Jacob

Disruptive behavior occurred least often when Jacob received 10 mg MPH (M = 1% of intervals; range, 0% to 4%), followed by 5 mg (M = 11% of intervals; range, 0% to 26%), then 7.5 mg (M = 14% of intervals; range, 0% to 39%), and finally placebo (M = 37% of intervals; range, 22% to 63%). The results were similar for inappropriate social behavior displayed by Jacob, except that more of this behavior occurred at 5 mg than at 7.5 mg. That is, inappropriate social behavior occurred least often when Jacob received 10 mg MPH (M = 15% of intervals; range, 9% to 22%), followed by 7.5 mg (M = 20% of intervals; range, 0% to 57%), then 5 mg (M = 39% of intervals; range, 13% to 61%), and finally placebo (M = 45% of intervals; range, 22% to 61%). The pattern of results obtained through teacher ratings on the ADHD rating scale was the same as for inappropriate social behavior. The teacher rated his behavior as most improved (i.e., the lowest score) when Jacob received 10 mg MPH (M = 12; range, 8 to 19), followed by 7.5 mg (M = 21; range, 12 to 27), then 5 mg (M = 23; range, 16 to 29), and finally placebo (M = 26; range, 20 to 37). Teacher ratings on the SDSERS never exceeded 3 on any item at any dose, and mean total scores were below 2 for placebo and the three doses.

The results for the reading task are presented in the fourth row of panels in Figure 1. The mean number of correct words was highest when Jacob received 5 mg MPH (M = 24; range, 21 to 27), followed by 7.5 mg (M = 22; range, 20 to 25), then 10 mg (M = 17; range, 11 to 20), and finally placebo (M = 14; range, 9 to 21). On the math task, the number of problems Jacob completed correctly was similar when he received placebo (M = 17; range, 15 to 19), 7.5 mg MPH (M = 17; range, 11 to 23), and 10 mg MPH (M = 19; range, 13 to 23), but was somewhat less when he received 5 mg MPH (M = 10; range, 2 to 17). The poorer performance on this measure at 5 mg may have been due to an aberrant data point for Session 2, during which Jacob completed only two problems correctly.

To summarize the results for Jacob, the measures of disruptive and inappropriate social behavior and the teacher ratings revealed clear differences between drug and placebo conditions at the highest dose (10 mg) but not at the two lowest doses (7.5 and 5 mg). The pattern of results on the reading task was almost directly opposite of that observed with the three previous measures. That is, although the mean number of words read correctly was higher than placebo for each of the drug doses, the differences were prob-

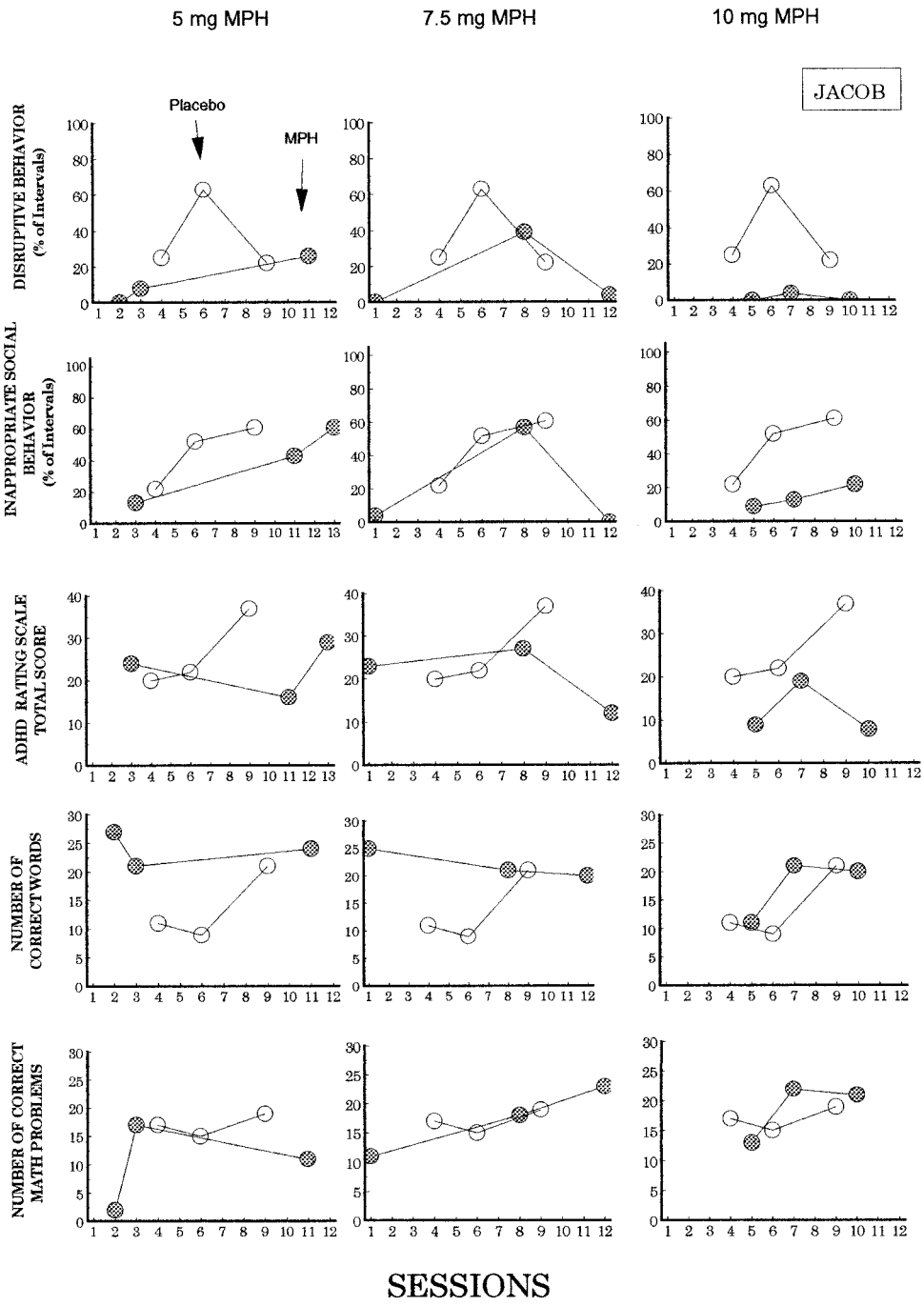

Figure 1. Results for Jacob across each dosage compared to placebo for percentage of intervals with disruptive classroom behavior (top panel), percentage of intervals with inappropriate social behavior (second panel), total score on teacher ratings (third panel), number of math problems completed correctly (fourth panel), and number of words read correctly (bottom panel).

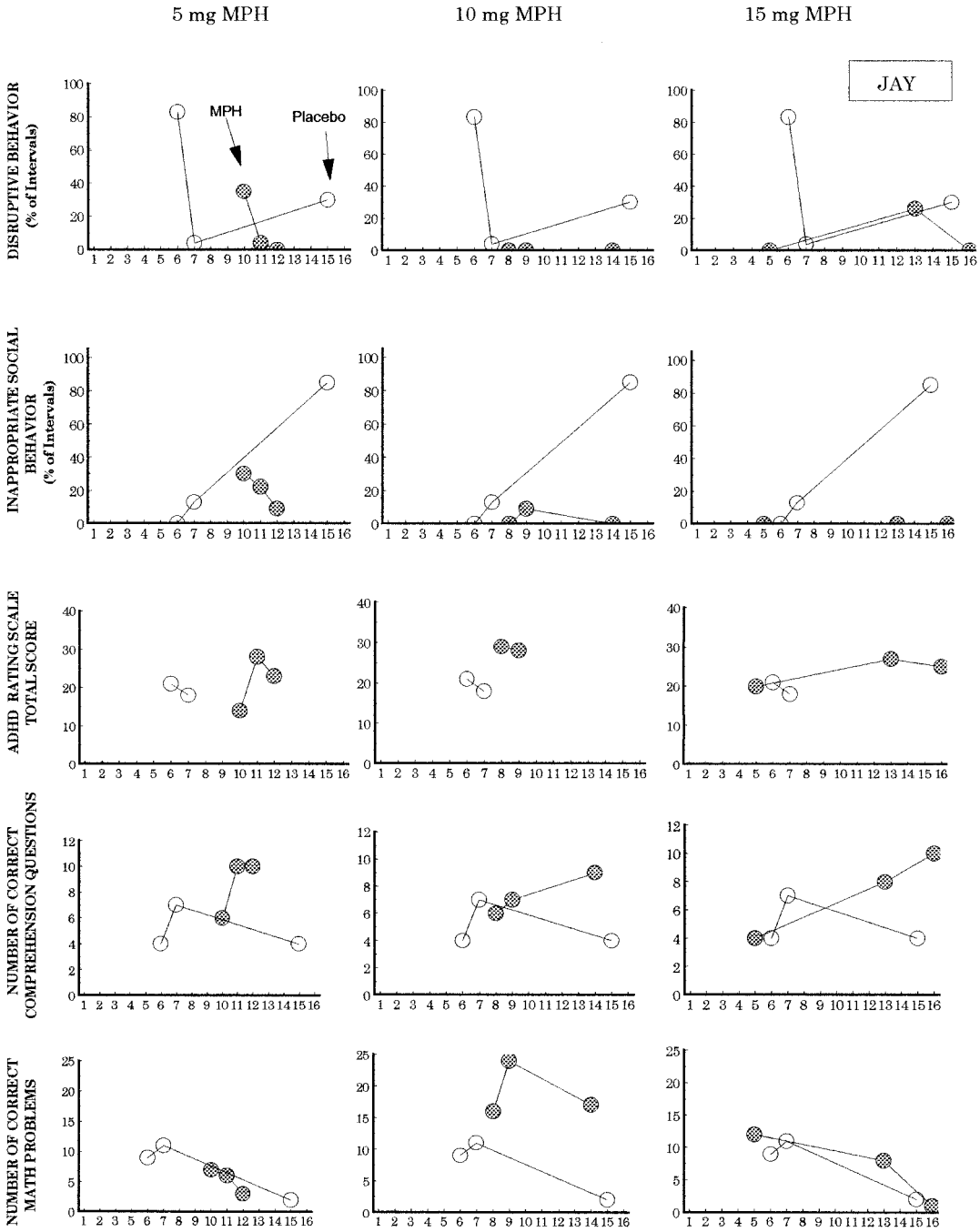

Figure 2. Results for Jay across each dosage compared to placebo for percentage of intervals with disruptive classroom behavior (top panel), percentage of intervals with inappropriate social behavior (second panel), total score on teacher ratings (third panel), number of math problems completed correctly (fourth panel), and number of comprehension questions answered correctly (bottom panel).

ably not significant for the 10-mg dose, somewhat more clear and significant for the 7.5-mg dose, and clearest for the 5-mg dose. Finally, no clear differences between drug and placebo conditions were evident on the math task, and no significant side effects were noted at any dose. Taken together, these results provided fairly clear evidence that Jacob benefited from treatment with MPH, but no single dose was clearly superior to the others across dependent measures.

Jay

As shown in Figure 2, disruptive behavior in the classroom occurred least often when Jay received 10 mg MPH (M = 0% of intervals), followed by 15 mg (M = 9% of intervals; range, 0% to 26%), then 5 mg (M = 13% of intervals; range, 0% to 35%), and finally placebo (M = 39% of intervals; range, 4% to 83%). The pattern of results for inappropriate social behavior was somewhat similar and indicated that Jay displayed the least inappropriate social behavior when he received 15 mg MPH (M = 0% of intervals), followed by 10 mg (M = 3% of intervals; range, 0% to 9%), then 5 mg (M = 20% of intervals; range, 9% to 30%), and finally placebo (M = 33% of intervals; range, 0% to 85%). The pattern of results obtained through teacher ratings on the ADHD Rating Scale was different from both disruptive classroom behavior and inappropriate social behavior. The teacher rated Jay's behavior as most improved (i.e., the lowest score) when he received placebo (M = 19.5; range, 18 to 21), followed by 5 mg (M = 22; range, 14 to 28), then 15 mg (M = 24; range, 20 to 27), and finally 10 mg (M = 29; range, 28 to 29). It is important to note that during the days that Jay received 10 mg and placebo, the teacher returned ratings on only 4 of the 6 days. Teacher ratings on the SDSERS were zero across all dosages.

The results for the reading task are also presented in Figure 2. Jay answered the greatest number of comprehension questions correctly when he received 5 mg MPH (M = 9; range, 6 to 10), followed by both 10 mg (M = 7; range, 6 to 9) and 15 mg (M = 7; range, 4 to 10), then placebo (M = 5; range, 4 to 7). On the math task, the number problems Jay completed correctly was similar when he received placebo (M = 7; range, 2 to 11), 5 mg (M = 5; range, 3 to 7), and 15 mg (M = 7; range, 1 to 12), but was substantially higher when he received 10 mg (M = 19; range, 16 to 24).

To summarize the results for Jay, measures of disruptive and inappropriate social behavior indicated clear differences between drug and placebo conditions at the two higher doses (10 mg and 15 mg), with very small differences between the two doses. The pattern of results from the teacher ratings was inconsistent with both of these measures, in that rating Jay's behavior was rated as best during the placebo condition. The pattern of results on the reading comprehension task indicated a higher number of questions answered correctly for each of the drug doses compared to placebo. However, these results were also almost directly opposite of that observed with the measures of disruptive and inappropriate social behavior, indicating clearest differences for 5 mg. Finally, the results from the math task indicated clear differences between drug and placebo conditions for the 10-mg dose but not for the other two doses (5 and 15 mg). Jay's results provided fairly clear evidence that he benefited from treatment with MPH; with the exception of teacher ratings, however, no single dose was distinctly superior across all dependent measures.

DISCUSSION

We conducted comprehensive individualized evaluations of the effects of MPH for 2 children in their usual classroom setting. To address several limitations of previous stud-

ies, evaluations included (a) repeated measures based on direct observation and CBM; (b) assessment across behavioral, academic, and social areas of functioning, as well as side effects ratings; (c) use of double-blind placebo controls; (d) assessment of three doses of MPH; and (e) use of single-case multielement designs. Results suggested that at least one or more dosages of MPH were associated with some degree of improvement for both children in each area of functioning compared to placebo.

CBM measures of academic performance and direct observations of classroom behavior appeared to be most sensitive to medication effects for both students. Both direct observation and CBM may be particularly useful for evaluating the effects of MPH because they can be relatively brief and reliable, and can be used repeatedly in the classroom. The combination of direct observation and CBM was shown to provide an efficient simultaneous assessment of MPH effects across disruptive classroom behavior, academics, and social behavior. Although teacher ratings corresponded with the academic, behavioral, and social measures for 1 participant, they did not correspond with these measures for the other participant. These results are consistent with previous suggestions that teacher ratings can be subject to informant bias and are often technically inadequate (Shapiro & Kratochwill, 1988; Stoner et al., 1994). Alternatively, teacher ratings may be considered to be an independent measure of some other unspecified behaviors that would not necessarily be expected to correspond with the other measures. Teacher ratings might also be of interest in and of themselves as a measure of "complaining" (Witt, 1990) or consumer satisfaction (Wolf, 1978).

Overall, the current procedures were demonstrated to be a relatively practical and efficient model for determining MPH effects compared to placebo and demonstrate the importance of dosage as well as placebo comparisons. The degree of improvement at times varied across dosage by area of functioning. This study also replicates the findings of Stoner et al. (1994), because CBM was again found to be a sensitive measure of stimulant medication effects. The results support the use of CBM as a systematic, efficient way to measure MPH and dosage effects, but also suggest the need to conduct individualized evaluations across behavioral domains. In addition, this study contributes to a relatively small literature that has evaluated the effects of MPH on children's social behavior (e.g., Pelham & Hoza, 1987). Results suggest that at least one dose of MPH was associated with a decrease in inappropriate social behavior for both participants compared to placebo.

One limitation of the current investigation was that optimal doses were not identified for these students. Typical methods of dosage selection such as age, body weight, or blood levels have not been shown to be consistently associated with a therapeutic response (Rapport, DuPaul, & Kelly, 1989). Published best practice recommendations for dosage selection also have varied, and thus the practices of individual physicians may at times appear to be rather arbitrary. Although physicians were asked to prescribe a low, moderate, and high dose, dosage selection appeared to be based on progressive 5-mg increments (perhaps the most common practice). However, this resulted in a rather restricted range of dosages for the current participants, and all dosage levels for both participants might be considered relatively low (0.1 mg/kg, 0.2 mg/kg, and 0.3 mg/kg). The use of higher doses such as 0.3 mg/kg and 0.6 mg/kg is more typical of previous research (e.g., Pelham et al., 1993). The evaluation of relatively low doses may have contributed to the frequently slight or equivocal differences in results between dosages for both students. However, it should be em-

phasized that very small improvements for academic dependent variables such as the number of words read and number of math problems completed could become a very large cumulative difference if multiplied over the course of a school year.

A second limitation was the relatively small number of sessions (i.e., three) that were conducted at each level of medication, and steady-state response patterns were not typically obtained. The requirements of a double-blind control (i.e., a predetermined number of sessions) can conflict with general principles of single-case design (e.g., condition changes based on demonstrated stability). Future researchers might develop a method for continuing phases across a greater number of assessment sessions.

Although it was not a purpose of this study to evaluate MPH effects in the context of any other interventions, it is recommended that behavioral interventions be conducted prior to and in combination with the use of medication (e.g., Pelham et al., 1993). There continues to be a need for further evaluation of the separate and combined effects of MPH at varying dosages and behavioral treatments at varying levels of treatment strength (Hoza, Pelham, Sams, & Carlson, 1992; Northup, Fisher, Kurtz, Harrel, & Khang, 1997). In addition, MPH effects should be considered in the context of ongoing and naturally occurring contingencies in the classroom (e.g., peer attention). There is a need to evaluate interactive effects between MPH and naturally occurring or programmed contingencies in the classroom (e.g., teacher reprimands, time-out). Future studies should include a follow-up phase (e.g., Stoner et al., 1994) to determine whether the results of a medication evaluation are consistent over time and in natural contexts.

In conclusion, this study provides a demonstration of the use of behavioral assessment and single-case designs to conduct school-based evaluations of MPH effects for individual students. Results suggest that the combined use of direct observation and CBM can provide a practical and relatively efficient method to systematically compare MPH effects to placebo, across dosages (or to other treatments), and across areas of functioning. The present results suggest that MPH dosage and area of functioning are critical assessment parameters and that controlled clinical trials may be necessary to optimize the effectiveness of treatment with MPH for the individual child.

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STUDY QUESTIONS

1. According to the authors, what three factors complicate a determination of the effects of methylphenidate (MPH)?

2. What types of dose–response relations may by observed during administration of active drugs?

3. What is meant by the term *curriculum-based measurement* (CBM)?

4. Briefly describe the dependent variables of the study.

5. The experimental design incorporated three different control features: double-blind observations, placebo, and multielement manipulation. What specific source of confounding was each control designed to address?

6. The results, shown in Figures 1 and 2, reveal a number of overlapping data points during placebo and drug conditions and inconsistent findings across measures. Nevertheless, when considering the overall results on (a) inappropriate behavior and (b) academic performance, what tentative conclusions can be made about the effects of drug versus no drug and the effects of drug dosage?

7. What explanations were offered by the authors to account for discrepancies between the teacher ratings and the other dependent measures?

8. In their discussion, the authors noted that two limitations of the study were the small number of sessions conducted at each drug dosage and instability in the data. They attributed this limitation, in part, to the requirements of a double-blind control by stating that such a control requires a predetermined number of sessions. Comment on the accuracy of this statement and suggest a solution to the more general limitations noted by the authors.

Questions prepared by Han-Leong Goh and Eileen Roscoe, The University of Florida